CEMENT
AND
CEMENT MANUFACTURE
INCORPORATING "PORTLAND CEMENT"

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The Meaning of Power Factor.

To make it clear why it pays the power user who operates on alternating current to improve his power factor it is desirable that he should first understand the exact meaning of the term. Briefly, it expresses the proportion of the current taken from the mains which is converted into mechanical power; in other words, the proportion of current effectively used to the total supplied. A better explanation can perhaps be given by analogy.

If we imagine water in place of electricity we can more readily understand what happens. The generating station pumps water to the factory in order that it may, under pressure, be used to drive machinery, thus giving energy in the form of mechanical power; it is this energy the consumer wishes to purchase, not the water. After the water has done its work it flows back to the power station to be pumped up again. This is just what happens with electricity. After it has given up its energy the electricity returns along the mains to the generating station, but in the case of alternating current feeding A.C. motors, owing to the peculiar characteristics of this type of motor, they fail to make full use of the electricity flowing from the mains and utilise only a proportion, say, 0.75. The remainder of the current (called "idle" or "wattless" current) not usefully employed is returned to the mains, and although the same amount of current that left the power house is returned only 75 per cent. has been converted into actual energy, the other 25 per cent. returning unused.

The result is that, in order to give the consumer the power he actually requires, the power station is compelled to provide larger plant and cables than would be necessary if his power factor were unity. Imagine a power station with plant generating 10,000 h.p. connected to a cement works whose power factor is 0.75; only 7,500 h.p. is actually utilised, as 25 per cent. of the power is returned unused. Nevertheless, plant of 10,000 h.p. capacity has to be installed, with consequent overhead expenses, to provide this 7,500 h.p.

On the other hand, a cement works using the same amount of power but enjoying a high power factor costs the supply company less for supply; hence tariffs based on costs of supply which necessarily vary with the power factor.

Improving Power Factor.

It is in the interest of both consumer and supply station that the power factor should be as high as possible, and the question arises as to the best methods to achieve this end. In the first place it is necessary that the power factor of all motors shall be high. Under the most favourable circumstances the power factor of the induction motor (the motor used on alternating current systems) of ordinary sizes is between 0.8 and 0.9. An A.C. induction motor gives its highest power factor when working at its maximum rated load, and this rapidly falls off when it is working on half load or below. This variation calls for the grouping of machines and the sizes of motors in such a manner that they all work as nearly as possible at their rated maximum capacity.

Taking the above precautions, the normal power factor of plant in a cement works using induction motors may well be maintained at as high a value as is possible without the use of special apparatus. It is still possible, however, further to improve the power factor, and this is accomplished by the use of (1) static condensers, (2) synchronous or auto-synchronous motors, (3) phase advancers.

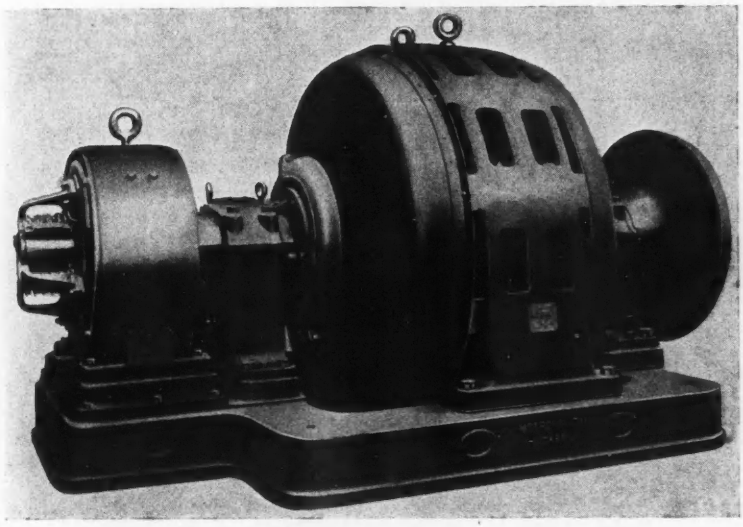
Static Condensers.

The static condenser consists of a large number of rolls of tin-coated paper built into frames and immersed in a tank of insulating oil hermetically sealed. The most economical voltage is 600, and where the electric supply is at, say, 420 volts, a step-up transformer is supplied with the condenser to raise the pressure to 600 volts. Static condensers are efficient, and as it is a motionless piece of apparatus it requires very little attention nor does it call for elaborate foundations. On the other hand the prime cost is relatively high, and should a breakdown occur it is as a rule necessary to return the whole apparatus to the manufacturer.

The efficiency of a condenser alone is approximately 99 per cent., and with transformers 98.5 per cent. in sizes over 100 k.v.a. The cost per k.v.a. for condenser and transformer, assuming 440-volt, 50-cycle supply, is about £2 10s. to £3 10s. depending on size; say, £300 for a 100-k.v.a. equipment. For 25-cycle supply the cost will be practically doubled.

Auto-Synchronous Motors.

With regard to the use of synchronous motors for power factor correction, manufacturers have designed a machine known as an auto-synchronous motor which is really a special form of induction motor which starts up against any reasonable load required in a similar manner to the ordinary induction motor, that is, by resistance in the rotor circuit. When the resistance is all cut out the motor continues to run as an ordinary induction machine, that is to say, it has a small slip, consequently it does not run at exactly synchronous speed. By applying a continuous current to the rotor windings, fixed poles are obtained

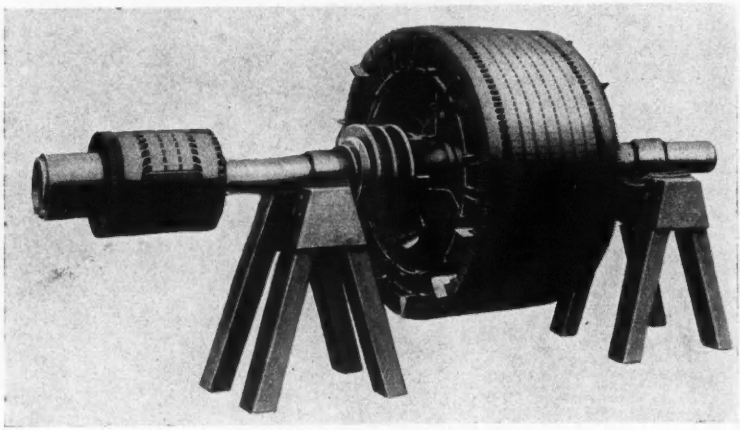


Synchronous Induction Motor as used at Cement Works.

in the rotor, causing this latter to pull into synchronism with the rotating field in the stator. While the ordinary synchronous motor cannot be started against any heavy load, and during starting does not develop more than one-third of the full load torque, taking a heavy starting current even to produce that, the auto-synchronous motor possesses the ideal characteristics of good starting and power factor correcting properties.

The low power factor of machines running light affects adversely the total power factor, so that whilst the individual power factor of each machine is good at full load, the fluctuations in the load of the whole installation bring the average power factor down to a low value. An auto-synchronous motor, on the contrary, running at light load will tend, according to its design, to give a greater leading wattless component available for advancing the power factor of the total installation; thus a fluctuating load is no disadvantage to an auto-synchronous motor.

It cannot be said that auto-synchronous motors are much more complicated and require more skilled attention than induction machines, as with the exception of certain internal modifications an auto-synchronous motor is essentially the same as an induction type with the addition of a D.C. exciter belt-driven by, or direct coupled to, the motor. The control gear is precisely the same as for an induction machine, consisting of circuit breaker with the usual protective devices and interlocked rotor starter. The motor is started up in the usual manner as an induction motor by closing the main switch and gradually cutting out the starting resistance. While running up to speed



Synchronous Induction Motor with Exciter Armature.

the exciter builds up the magnetising current, and on approaching full speed the motor pulls up automatically into synchronism.

It may be asked what happens to the machine should an overload occur during running. Normally an auto-synchronous motor which is only arranged to give of itselt a power factor of unity, instead of a large leading power factor, means that the excitation of the rotor circuit is comparatively feeble; consequently if the machine is subjected to intermittent overloads of a heavy nature it might easily pull out of step. For machines driving reciprocating compressors it is therefore always desirable to arrange them to give a leading power factor of 0.9. In actual practice the power factor has usually more than this to correct, the lagging current arising from a number of induction motors running on the same circuit.

If for any reason the auto-synchronous motor becomes heavily overloaded nothing serious happens, as directly the machine falls out of step it will continue to run as an induction motor. This is a valuable feature under practical working conditions. When out of synchronism the motor immediately recovers the characteristic of an ordinary induction motor with its heavy overload torque, and when the excessive overload is removed it again pulls automatically into synchronism and resumes its duty of correcting the power factor without any attention on the part of the operator.

The chances of a breakdown to the exciter of the machine are remote, but in such an event the auto-synchronous motor need not necessarily be idle during the time required for repairing the exciter as the latter can be uncoupled and the motor used as an ordinary induction motor. Under this condition it would give an output of approximately 75 per cent. of full load continuously, depending upon the speed of the machine. Auto-synchronous machines can be designed

to operate purely as rotary synchronous condensers, their duty being entirely electrical, *i.e.*, power factor improvement without any mechanical load. Such machines, however, can also be used for giving mechanical output when required.

Phase Advancers.

It is perhaps only necessary to touch briefly on phase advancers as they are not used to any great extent in this country. A phase advancer is a separate rotating machine with a commutator, and is used in conjunction with a slip-ring induction motor. It injects a leading e.m.f. into the rotor of the induction motor, which has the effect of making the stator current attain unity power factor or draw a leading current. The phase advancer is useful in the case of a motor working in conjunction with a flywheel, and a drop of speed is desired to allow the flywheel to release its stored kinetic energy. It is obvious that a flywheel on the shaft of an auto-synchronous motor, with its constant speed, is of little use to equalise the power demand when dealing with sudden peak loads such as may obtain in cement works.

[Our illustrations are by courtesy of the Metropolitan-Vickers Electrical Co., Ltd.]

Imported Portland Cement.

THE Standing Committee appointed by the Board of Trade will hold an inquiry at 11.30 a.m. on July 29, as to whether imported Portland cement should bear an indication of origin. The inquiry will be held at the Board of Trade Offices, Great George Street, London, S.W.1. Communications should be addressed to the Secretary, Mr. E. W. Reardon, at that address.

Belgian Cement Prices.

A GERMAN contemporary reviewing the position in the Belgian cement industry during 1928, states: " The past financial year has generally shown gratifying business results for the Belgian cement industry. The industry has for the greater part of the year been able to work to full capacity. The home demand was generally moderately good, and business done on the export market was more active than the previous year. Competition was most clearly reflected in the home wholesale prices. In the first quarter cement was sold on the basis of 170-180 Frs. (19/5 to 20/5) per ton f.o.r. factory. In the two following months there was a fall in prices, *viz.*, 165-170 Frs. (18/11 to 19/5), followed by a consolidation at 170-175 Frs. (19/5 to 19/11) in June and July. The most noticeable set-back in prices took place from August to October, *viz.*, 140-165 Frs. (16/- to 19/-), while the year closed with prices at 165 to 170 Frs. (18/11 to 19/5) as against 180 to 190 Frs. (20/5 to 21/5) at the end of the previous year. Belgian cement exports for 1928 amounted to about 1,800,000 tons, an increase of about 7 per cent." (The price of cement in Belgium was raised by Frs. 10 per ton from March 15 this year.)

Capital Costs and Costs of Manufacture.

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THE cost of production of Portland cement, apart from selling costs, depends mainly upon five items, *viz.*, capital expenditure; labour and supervision; fuel; power; and renewals and repairs.

Capital Expenditure.

The construction costs of a new factory will depend upon many factors, the first of which are the locality in which the works are to be erected and the nature of the site, followed by other considerations such as the type of plant and machinery chosen, the class of buildings to be erected, the nature and amount of storage to be provided for coal, raw materials, clinker, and cement, whether power is generated or bought, and so on. On the last point, modern trend is in the direction of the all-electric drive with power purchased from central generating stations, and this arrangement very substantially reduces the capital required per ton of annual output for the equipment of a new cement works.

In most cases the relative advantages of reduced capital costs or reduced running costs may call for a very careful review of details before a decision can be reached as to the course likely to prove most economical in the long run. Broadly speaking, however, the general high level of wages in the English cement industry to-day requires that labour-saving appliances shall be adopted to the fullest extent, even in cases where little advantage could formerly be shown.

In view of the present-day wages which are normally payable for overtime and week-end work, and the increasing tendency to restrict hours of labour, it will often be found good policy to equip the raw material, clinker-grinding, and shipping departments on a scale which will enable the output of the kilns to be dealt with during a much less period than the full 168 hours of a week which the kilns must necessarily be run. This entails increased capital expenditure for additional machinery in the departments concerned, which will only be productive for a part of the week, but the cost of this may be more than offset by economy in running costs.

Cost of Production.

The three chief items of works' running costs are labour and supervision, fuel, and power. The two former normally comprise about half the total factory costs, and the cost of power about half of either of them. Repairs and renewals are a heavy item. In addition to the factory cost the total cost of production must include administration and sales costs, insurances, rates and taxes, depreciation and obsolescence of plant, as well as reserves and losses—generally an item as large as any other in the cost of production.

The subject of factory costs can, however, only be generalised upon, since the specific data upon which costs can be calculated vary considerably according to circumstances such as position, raw materials, and tonnage output.

Of the factors in cement manufacture which may influence the cost of production, the first is the question of the wet versus the dry process. The arguments in favour of both are numerous, and they introduce subsidiary questions such as the effect on quality. A decision is, however, usually influenced very largely by the nature of the raw materials, and the pros and cons of this were dealt with in the last number.

Except under very unusual conditions, no other than a rotary kiln plant would be recommended for modern conditions which demand high quality, minimum labour, and large manufacturing units, although the best dimensions for such kilns is a subject upon which different opinions are held. There is a greater prospect of economy in rotary kiln operation than in other departments of manufacture, and it is important to decide the relative advantages of the short kiln, the long kiln, the kiln with the enlarged burning zone, the enlarged calcining zone, or the enlarged slurry zone. This subject again will be dealt with in a future article, but the decision affects both capital and production costs.

The coal to be used in the manufacture is usually determined by consideration of price, but in some cases there is a choice between coal with a high volatile content and a low volatile content, or between low-priced coal with much ash and an expensive coal of high calorific value. The degree of fineness of coal grinding is bound up with the quality of coal, and in its turn introduces the question of the best type of mill for the purpose—the unit pulveriser, the tube mill, or the pendulum mill. The bugbear of clinker rings and their disastrous effect upon continuity of kiln operation is also related to coal quality and fineness, and all these considerations will be dealt with in more detail later.

In England the ordinary silicious firebrick was generally used until a few years ago, since when a more costly brick containing over 60 per cent. of alumina has come into favour. The works manager has to decide whether these high-priced aluminous bricks are worth while. Does it pay to use a common firebrick with a life of four months rather than an aluminous brick at three times the price and with a prospect of a much longer life?

For the utmost economy a rotary kiln must run continuously and with the minimum coal consumption, but then the question arises whether the output per running hour should be increased to an extent involving additional fuel consumption per ton of clinker; and, again, whether a high running output necessarily connotes a high fuel consumption.

When all these questions have been decided there are many others of perhaps less prime importance which will affect manufacturing costs in some degree.

The whole of the constituents which enter into cement manufacturing costs may be summarized as follows:—

(1) **Raw Materials**: Cost of chalk or limestone.
Cost of clay or shale.

(2) **Labour**: Manufacturing.
Repairs.
Packing and shipping.

(3) **Fuel** for burning and drying.

(4) **Power.**

(5) **Other Supplies, etc.**: Gypsum.
Machinery parts and stores, including lubrication.
Haulage and transport.
Miscellaneous (upkeep of buildings, permanent way, lighting, etc.).

(6) **Overhead Charges**: Administrative and management expenses, including office, laboratory, etc.
Depreciation and obsolescence of plant and machinery.
Rates and taxes.
Insurances.
Depletion of raw material reserves.

(1) **Raw Materials.**—The cost of raw materials for Portland cement differs within wide limits between one plant and another. Factors affecting it are royalties payable, the nature and accessibility of the deposit, its hardness, the amount of overburden, the depth available (particularly above water level), and its proximity to the site of the works. A hard stone which requires drilling and blasting before it can be handled will necessarily cost more per ton than soft shale which can be dug direct with a digger. Again, as the removal of overburden is an unremunerative operation it adds to the cost in proportion to its depth.

If there is little material available above water level it may be necessary to go lower, in which case the cost of continued pumping is incurred except in the case of clay or soft chalk which can be dug below water. Distance and means of transport to the works may vary considerably. If the quarry is reasonably close to the works it may be found convenient to erect the crushing or washing plant actually in the quarry, and when the wet process is adopted the slurry ready for the kilns can conveniently be pumped to the works. On the other hand it may be necessary to load the materials into trucks or vessels and convey them for long distances.

(2) **Labour.**—In England the cost of labour for cement manufacture is affected by the very much higher rates of pay as compared with Continental countries, coupled with other advantages to labour such as the 48-hour week, high rates for overtime, holidays, and so on. Wages rates also vary somewhat as between one part of the country and another.

Hand labour is therefore replaced by machinery in every department of the modern factory, and an output of two tons or more per day for every man

employed on manufacturing operations may be looked for on a modern plant. This takes no account of hands employed on repair work or on packing and shipping, and is of course only an approximate guide. It varies with the lay-out and equipment of the factory, and especially in cases where raw material or power may be purchased.

(3) **Fuel.**—It has already been said that the type of coal to be used is usually settled by considerations of price; this particularly applies to the coal used for burning, where something like one quarter of the expenditure in manufacturing cement is incurred. There are, of course, some coals which are so high in ash, or otherwise unsuitable, that they are not satisfactory no matter how cheap they may be. In England, however, bituminous coals of fair quality are so readily obtainable that price becomes the final arbiter, and this in turn is affected by the relative positions of cement works and collieries and the means and cost of transport. In the best modern practice from 5 to 6 cwt. of coal of 12,600 B.T.U.'s per lb. is used for burning a ton of cement on the wet process, and approximately 1 cwt. less per ton on the dry process. Oil is not used in English works as its cost is high in comparison with coal.

(4) **Power.**—Coal for power is usually of a more specialised character depending upon the type of power plant to be used, and as the tonnage required is so much smaller than that used in burning the higher cost of the selected quality is not of such serious import. If waste-heat boilers are installed and power is obtained from the kiln gases, then the quantity of power coal required is further reduced.

Where electric power is purchased from a generating station its cost is usually arranged on a sliding scale, subject to coal prices and other factors. Agreements for such supplies customarily contain provisions for peak and minimum loads, and in designing a new plant a careful balancing of units should be made in order to secure a constant load factor.

(5) **Other Supplies, etc.**—Gypsum, stores, lubricating oils, etc., are items which are usually purchased in a competitive market, and costs can be calculated fairly accurately as a rule. About 3 per cent. of raw gypsum stone is likely to be used, and the present cost of this in the United Kingdom will probably be about 15s. to 20s. a ton. Some cement works have contracts under which their requirements of lubricants are supplied at a fixed price per ton of cement produced.

Haulage and transport, again, are much influenced by the situation of the works in relation to raw materials and markets.

Machinery repairs and replacements are usually a heavy item in cement works costs, and the saving which can be effected under this head in designing a new plant is often considerable. The item, of course, tends to rise in every plant as time passes, and cement works machinery, notwithstanding its robust construction, has a relatively short life.

(6) **Overhead Charges.**—The cost of administration and management is

usually in inverse ratio to the output; the larger the plant the less the cost per ton under this head.

Rates, taxes and insurances are heavy items in this country to-day, and the home manufacturer has a handicap under this head equal to probably 6 to 8 per cent. of his manufacturing costs.

Allowances for depreciation and obsolescence of plant and machinery should be at least 5 per cent. of their first cost, and may well be 10 per cent. in some cases if a sound and conservative financial policy is pursued.

Charges for raw materials, depletion, and reserves will depend upon very variable factors.

Belgian Cement Industry.

THE following is taken from a report by the Commercial Secretary to the British Embassy at Brussels, entitled "Economic and Trade Conditions in Belgium" (London: H.M. Stationery Office, price 4s. 6d. net):—

"The cement industry continues to be prosperous, and exports during 1928 again showed a considerable increase. Even trade with the United States of America, notwithstanding the campaign in favour of home production, has improved. Exports to France were, however, halved owing to the raising of import duties. The United Kingdom took about 100,000 tons less than in 1927; this is said to be due principally to the decrease in building. On the other hand, exports increased to Argentine and Holland and other markets.

"The cement industry now counts twenty-nine works provided with rotary furnaces. Their annual output is estimated at 2,500,000 tons, or about 15 million barrels of 170 kilos net weight. Although certain amalgamations have taken place the movement is not widespread, and severe internal competition has tended towards reduction in price. One group, however, controls an output of 850,000 tons or 5,000,000 barrels, about one-third of the total output.

"An agreement has been arrived at between Belgian and German manufacturers and the works at Maestricht in regard to sales in Holland. Negotiations are still proceeding with a view to regulating sales on the home market, and if agreement is reached by all cement works each member of the organisation will be allotted a certain percentage of the consumption of the country according to the output of each factory. A fine will be payable if the quantity is exceeded, and any firm unable to produce the authorised quantity will be entitled to an indemnity.

"The total quantity of cement shipped abroad for the 12 months ending December 31, 1928, was 1,816,336 tons, as compared with 1,654,637 tons for the same period in 1927. The chief markets were Great Britain (221,311—323,011 tons in 1927), Holland (464,933), United States of America (267,050), the Argentine (200,140), Brazil (87,890), Egypt (75,487), France (49,831). All markets showed increased sales, except Great Britain and France."

Electrical Equipment at the Barnstone Cement Works.

THE Barnstone Portland Cement Works has been established for many years at Barnstone, Nottinghamshire. Recently the Company has installed an entirely new plant with up-to-date machinery and modern labour-saving devices, which is electrically operated throughout. The contract for the supply and erection of the new machinery was carried out by Messrs. Edgar Allen & Co., Ltd., whilst the electrical equipment, including switchboards, motors and motor control gear, was manufactured and supplied by the General Electric Co., Ltd. Some indication of the extent of the electrical equipment may be gathered from

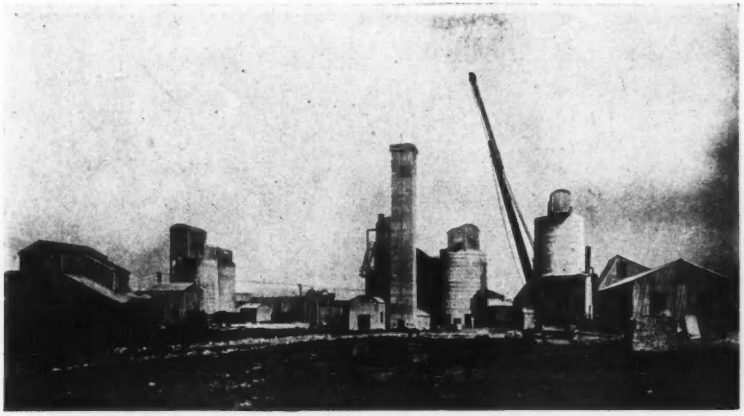


Fig. 1.—General View of Barnstone Cement Works.

the fact that the total normal capacity of the motors is approximately 2,000 h.p., ranging in individual outputs from 5 h.p. to 450 h.p.

The use of electricity for driving cement works machinery offers many important advantages over older types of driving units employed. The fact that the electric motor is so suitable for individual drive permits of the machines used at the various stages of manufacture being grouped to better advantage than if their relative positions were determined by the driving machinery; moreover, the electric motor can often be accommodated in small spaces which otherwise would be wasted. Ease of control is another very important feature of electric driving, while by installing ammeters as part of the control unit the power taken by any machine can readily be ascertained. Frequently the knowledge that a machine is taking more power for driving than it should will enable faults to be detected in an initial stage which otherwise might lead to much more serious trouble, perhaps involving the shutting down of plant for some days.

Electric power is taken from the 11,000-volt mains of the Derbyshire and

Nottinghamshire Electric Power Co. It is transformed down in the Power Company's sub-station at the works and fed at 440 volts to a G.E.C. truck cubicle switchboard, consisting of three units. Two of these control the low tension side of transformers, each being equipped with type 4 G.E.C. oil-circuit breakers of maximum breaking capacity of 100,000 Kva, fitted with overload protection, together with isolating links, measuring instruments, instrument transformers, etc. The third truck is an outgoing metering cubicle equipped with maximum-demand watt hour meter, voltmeters, and the necessary instrument transformers. The outgoing cables from this cubicle are led to the truck-cubicle feeder board shown in Fig. 2, which distributes power to the motors driving the machinery via ironclad distribution boards, control pillars, etc., as required. The principal equipment of each of the trucks comprises an oil circuit-breaker of suitable breaking capacity fitted with overload protection, watt hour meter, ammeter, and necessary accessories.

The G.E.C. truck-cubicle board occupies a minimum of floor space; the

Fig. 2.—440 Volt Truck Cubicle Feeder Switchboard supplying power to the Works.

apparatus is readily accessible for inspection as it is mounted on a truck which can be easily withdrawn from the cubicle providing the oil circuit breaker is open, and due to this provision safety to the operator is ensured, as the truck cannot be withdrawn while the breaker is closed. In addition, the withdrawal of the truck causes a shutter to fall, completely covering the holes through which the movable contact plugs pass in order to engage with the fixed contacts on the busbars. It will thus be seen that live metal is never exposed.

The cement produced in these works is manufactured on the wet process, burning in a rotary kiln. The raw materials mainly consist of blue lias limestone, which is quarried on the site, with the admixture of a certain quality of stone containing a high percentage of calcium carbonate. These raw materials are delivered in full-gauge trucks to a large jaw crusher, which reduces it in one operation to about 3 in. and under. The stone is mechanically fed to the

crusher by means of a finger feeder, consisting mainly of heavy grid bars with spaces between them and arranged at a slight slope to the horizontal. Some of these bars have a rocking movement backwards and forwards given to them by a driving shaft carrying eccentrics, and by this means the stones move forward towards the crusher jaws. This crusher and feeder is belt-driven by a 125-h.p. " Witton " motor running at 580 revolutions per minute.

The crushed stone falls on to a slightly inclined troughed band conveyor and is fed into a rotary screen, the rejects from the screen passing on to a set of medium-speed crushing rolls, 30 in. in diameter by 20 in. wide, where they are

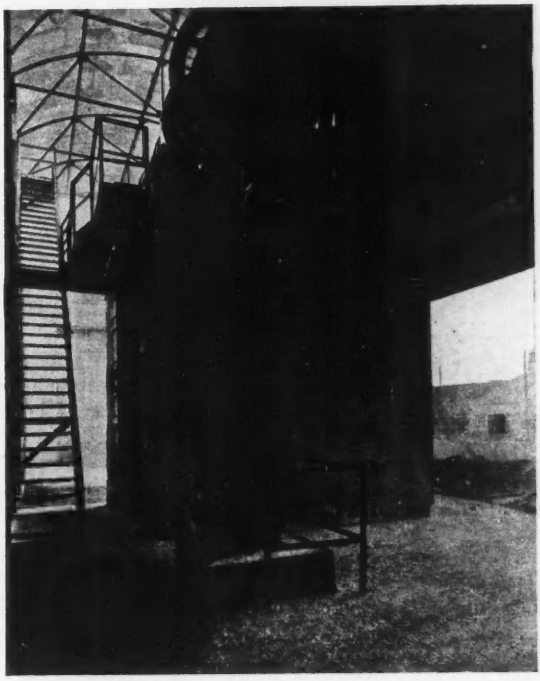


Fig. 3.—30-h.p. Three-Phase Variable-Speed Motor, 357/715 r.p.m., driving Rotary Kiln.

reduced to about 2-in. cube and under. The stone is then elevated by a continuous-bucket elevator and deposited on to a steel-band conveyor over two large reinforced concrete storage silos containing the two qualities of raw stone. These silos are hoppered at the bottom and rotary-table feeders are fitted at the outlets, by which means the raw stone is measured in the proportions required to give the correct chemical composition.

A band conveyor takes the raw stone to the grinding mill, which is a " Stag "

combination ball and tube mill, 6 ft. diameter by 32 ft. 6 in. long, grinding wet, water being fed in with the stone. The mill is of sufficient capacity to prepare the ground slurry for the plant. It is driven by a 300-h.p. " Witton " motor running at 244 r.p.m., direct coupled to the mill countershaft. The motor is housed separately from the mill. The power for supplying this motor is controlled by a G.E.C. draw-out oil-immersed ironclad pillar; the draw-out features embodied in this pillar are similar to those of the truck-type cubicle already described. The motor is operated by a G.E.C. type IV liquid controller.

The slurry as it comes from the mill is elevated by a slurry wheel, 28 ft. diameter, carrying buckets on its periphery, and runs by gravity to two triple mixers. The finished slurry runs by gravity into a large storage mixer of the " sun and planet " type, from whence it is pumped by means of three throw-plunger pumps direct to the kiln, which is belt driven by a 30-h.p. " Witton "

Fig. 4.—450-h.p. Three-Phase Motor driving 36-ft. Combination Tube Mill.

variable speed motor with a range of 357-715 r.p.m. The coal for the kiln is delivered from trucks direct into a feed hopper, and elevated to a large storage hopper over the pulverisers.

Two turbo pulverisers are installed, each driven by an 80-h.p. " Witton " motor, running at 1,450 r.p.m., which is direct coupled to the pulveriser shaft, and carried on the same bedplates as the machine. One pulveriser is of sufficient capacity to provide powdered coal for firing the kiln, the other machine being used as a standby. The coal is pulverised, air separated, and blown into the kiln in one operation, and coal up to 10 per cent. moisture content is used.

The kiln is fitted with the Rigby-Allen patented slurry atomising equipment at the feed end, and an induced-draught fan is provided for dealing with the waste gases. The hot clinker as it comes from the kiln passes through a rotary cooler, 5 ft. diameter by 55 ft. long, and is handled from the cooler end by

means of an Allen " swing tray " conveyor, which either delivers the clinker to the storage silos or direct to the cement grinding mill.

The cement mill consists of a " Stag " combination tube mill, 6 ft. 6 in. diameter by 36 ft. long, driven by a 450-h.p. three-phase " Witton " motor running at 244 r.p.m., direct coupled in a similar manner to the raw mill. This motor with its liquid starter is shown in Fig. 4, the control being similar to that of the 350-h.p. raw mill motor.

A small plant is provided for crushing and feeding gypsum, and automatic table-feeders are used for regulating the feed of clinker and gypsum to the mill in the right proportion. The ground cement is elevated and conveyed to three large reinforced concrete silos, whence it is extracted and packed mechanically into bags for despatch.

Reference has been made to the control of the 300-h.p. and 450-h.p. tube-mill motors. The other motors are controlled by suitable pillars, or panels, consisting in general of an oil circuit-breaker with starter. In the case of motors from 30 h.p. to 125 h.p. the starter is of the oil-immersed rotor pattern, whilst for the smaller motors auto-transformer starters are employed. The main power wiring consists of paper-insulated lead-covered cables, single-wire armoured, except between rotor starters and rotors where the cable is in flexible tubing.

The extensions described in this article were carried out under the direction of Mr. J. Ward, Managing Director of the Barnstone Cement Co., Ltd., to whom we are indebted for permission to publish the information and photographs.

Proposed Uruguayan Cement Factory.

The Bank of London and South America, Ltd., reports as follows: " A member of the National Administrative Council of Uruguay has presented a project to that body which aims at the construction of a new factory on up-to-date lines and provides for a capital of $4,000,000, three-fourths of which would be apportioned to the State. For some years past the output of cement has been in the hands of the Uruguayan Portland Cement Company, whose only difficulty appears to be to cope with the greatly increased demand brought about by new methods of building and by the extensive construction of concrete roads. A second project stipulates for the immediate removal of Customs duties on imported cement until such time as the new establishment controlled by the State may commence to operate."

Russian Cement Extensions.

The Seucholoshsber Cement Works in the Urals has been re-commissioned with an annual output of one million barrels.

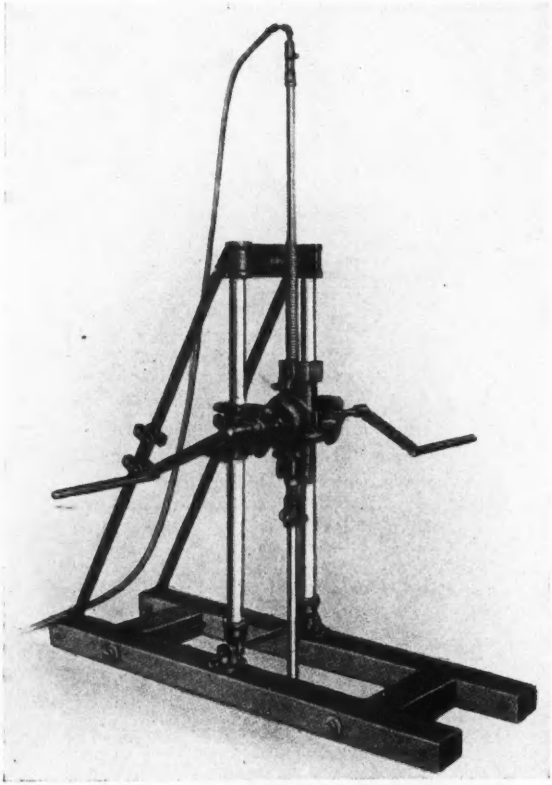
The Newgansker Cement Works is having its annual output of 300,000 barrels doubled by 1930.

Sampling Raw Materials for Cement Manufacture.

By A. REID-KELLETT.

FOR the comprehensive sampling of raw materials for cement manufacture, consideration might well be given to the use of small hand-power diamond drills as used by the mining profession for the sampling of mineral deposits, coal, etc. The advantages of the drills are cheapness, accuracy, mobility, and simplicity.

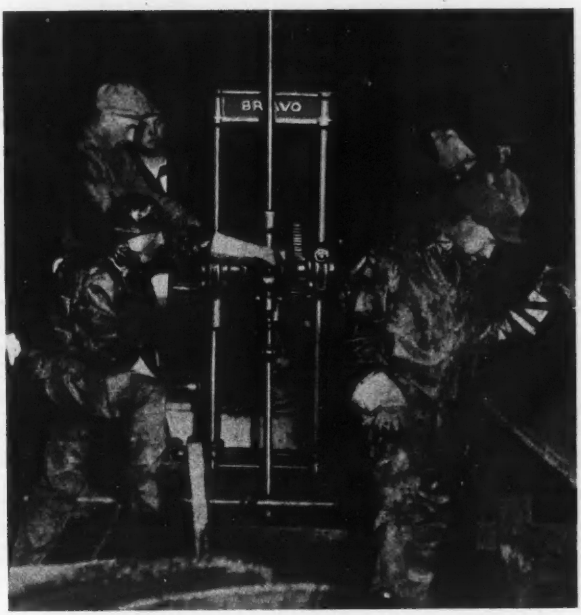
The author first came into contact with one of these drills several years ago when testing a coal deposit in Brazil. This machine gave excellent and accurate results, drilling to a depth of 300 ft. at a cost of 3s. 6d. per foot. It is rarely necessary to drill to such depths on bodies of raw materials intended for cement



Small Hand-Power Drill for Sampling.
(Weight, 1,085 lbs., Heaviest piece less than 150 lbs.)

manufacture, and in consequence less drilling rod is required and the first cost of the machine is also less. During the war I used one of these drills in the front line trenches on the Western Front. Working under appalling conditions it gave very good results; drilling a 3-in. diameter hole in hard chalk, it averaged 12 ft. per hour for 1,700 ft. of drilling, and the best speed recorded was 28 ft. per hour for four hours.

For sampling hard crystalline limestone it is necessary to use the diamond set bit. The diameter of the hole is $1\frac{1}{4}$ in., and the core obtained is $\frac{3}{4}$ in. diameter. Drilling speed with the diamond bit rarely exceeds 1 ft. per hour. For drilling



Diamond Drill in Use in Mine.

in chalk or clay the diamond bit is not required and a core is not obtained, but slurry only. Larger holes, however, can be drilled (up to 4-in. diameter if necessary, or even larger). A crew of four men and a foreman with some mechanical knowledge are required to run the machine, and its mobility is such that it can be erected and dismantled in half an hour. The heaviest piece weighs 180 lbs., and the weight of the whole, with 200 ft. of rods, is under a ton.

The gear-case and rod-holder are mounted on a hollow-steel tubular frame, and the drill can be set to bore at any angle. This is a great advantage, as the machine can be set to bore at right angles across the strata of any deposit that has been tilted away from its original alignment by upheavals after its

deposition. The first cost of a drill capable of drilling holes up to 400 ft. in length is about £200, and such a machine, if handled with reasonable care, will drill from 60,000 to 100,000 ft. of holes at a very low maintenance cost.

The more important mining companies with world-wide interests have machines and crews which are sent from place to place, and it has been found that comprehensive sampling and estimating can be carried out in this way at a cost that is only one-third of the old-fashioned shaft-sinking and blasting. Fig. 1 shows a small hand-power drill weighing 1,085 lbs., and the heaviest piece of which weighs less than 150 lbs. Fig. 2 shows a machine in use in reaching a guide who was entombed in some caves in the United States.

The Portland Cement Industry in Japan.

IN a recent number of the Journal of the Society of Chemical Industry (Japan), Mr. Shoichiro Nagai contributed a review of recent advances in the Japanese Portland cement industry. In the last five years, he said, the Portland cement industry of Japan has made remarkable progress, as shown in Table I. The total capacity of mills is now estimated at about 26,000,000 barrels per year, and it will become 28,500,000 barrels in 1929.

TABLE I.

	Production in Barrels.	Number of Factories.	Capital in 1,000 Yens.
1924	12,764,000	32	121,315
1925	14,559,000	34	121,450
1926	18,610,000	35	129,910
1927	21,053,000	34	187,410
1928	22,400,000 (Estimate)	33	191,377

The manufacturing process is, in general, the dry process, but the wet process is being adopted by the newly-established factories. The size of the factories has doubled in five years as shown in Table I. The change of size of rotary kilns and tube type mills is shown in Table II.

TABLE II.

	Number of Rotary Kilns (Length in Metres)						Maximum Size of Tube Type Mills (Dia. × Length)
	20m	20 to 30m	30 to 40m	40 to 50m	50 to 60m	60m	
1922	6	5	24	6	5	11	2.134m × 7.315m
1924	3	5	34	15	3	16	2.134 × 7.925
1928	3	5	31	17	3	22	2.000 × 13.000

The recovery of waste heat from rotary kilns was first adopted in Japan in 1920, and there were 43 waste heat boilers in 1927 with a total heating surface

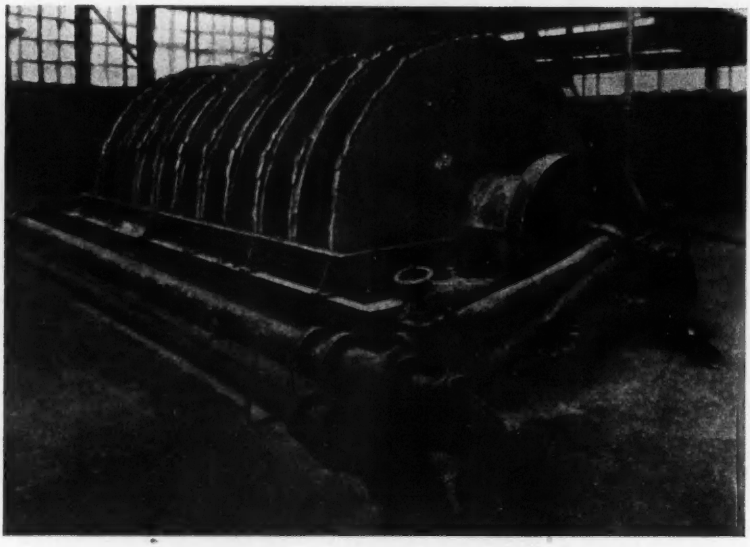
of 32,544 square metres, and 29 turbo-electric generators with a total capacity of 54,410 KW, corresponding to nearly 80 per cent. of the power used in the industry. The Japanese Standard Specification for Portland Cement was first issued in 1905 by the Government, and was revised in 1913, 1919 and 1927. Table III gives the results of tests and analyses of 28 brands of Portland cement as made in Japan in 1928.

TABLE III.

		Mean.	Max.	Min.	Standard Specification JES 28 1927.
Fineness (4900 M/cm², %)		3.7	8.0	1.5	< 17.0
Specific Gravity		3.144	3.180	3.105	> 3.05
,, ,,	Ignited	3.181	3.220	3.125	
Time of Setting	Water %	25.9	28.0	24.2	
	Initial h. min.	2 53	4 15	1 47	> 1
	Final h. min.	4 34	6 46	3 13	< 10
	Room Temp. °C.	20.0	22.8	15.0,15°	~25°C.
Strength (kg/cm²) Tensile Strength Neat	Water %	15.5	16.7	14.0	
	7 d.	76.4	95.4	59.5	40.0
Tensile Strength 1. Cement 3. Jap. Standard Sand	Water %	6.7	7.3	5.8	
	3 d.	28.7	35.3	24.0	
	7 d.	33.1	37.3	22.0	14.0
	28 d.	38.8	43.1	35.1	21.0
Compressive Strength 1. Cement 3. Jap. Standard Sand	Water %	6.9	7.4	6.2	
	3 d.	322.0	429.5	202.5	
	7 d.	444.7	586.0	305.4	
	28 d.	562.8	701.0	440.0	210.0
	1. Air / 6. Water / 21. Air	636.4	770.0	573.5	
Chemical Analysis	Ig. loss	1.09	1.98	0.57	< 4.0
	Insol. Res.	0.36	0.63	0.05	
	SiO_2	22.09	23.32	20.48	
	Al_2O_3	5.66	6.74	4.42	
	Fe_2O_3	3.16	4.04	2.30	
	CaO	64.79	66.07	63.03	
	MgO	1.26	2.16	0.72	< 3.0
	SO_3	1.23	1.62	0.83	< 2.0
	Total	99.64			
Temp. of Tank Water °C.	3 d.	18.5	21.1	13.0	>10°C.
	7 d.	18.2	21.0	12.0	
	28 d.	17.9	21.0	12.0	

Slurry Filters.

THE Federal Portland Cement Co.'s plant at Bay View, just outside of the city of Buffalo, N.Y., is stated by " Rock Products " to be the only Portland cement plant employing the wet process and using an air-cooled slag and limestone as raw material. It is one of the two existing plants that have been built with slurry filters as a part of the original design. There is a connection between these facts. In the opinion of those operating the plant it might be possible to run without filters, but it would not be so easy and it would be a great deal more expensive. The ability to keep the slurry at exactly the moisture content desired has been responsible for comparative freedom from mechanical



Slurry Filters: Air Pipes in Foreground.

difficulties. With slag the filters pay for themselves in other ways than reducing coal consumption although they are as successful in that as they are in plants using other materials.

With the dry process slag presented no difficulty, but when it was attempted to use the wet process with slag and limestone operating difficulties arose. The slurry set in the storage tanks and choked the pipes through which it was pumped. The addition of sugar or dextrine to the slurry tended to prevent this, but there were reasons why this method was not entirely satisfactory.

At the Federal Portland Cement Co.'s plant at first fine metallic iron settled in the pipes and choked them. A thicker slurry prevented the fine iron from settling, but gave trouble by building up on the sides of the slurry tank.

(*Continued on page* 207.)

Finally, it was found that by carrying 39 to 40 per cent. of moisture in the slurry both these difficulties were obviated. A slurry of this consistency was found to be thick enough so that the fine iron would not settle with the ordinary velocity of pumping through pipes, and sufficiently mobile so that it could be kept in thorough agitation in the slurry tanks which prevents " pasting up " on the sides of the tanks. There is still some settlement, so that a slurry tank has to be cleaned out occasionally, but this does not happen often enough to interfere with regular production or entail any appreciable loss. The 40 per cent. moisture is satisfactory for every part of the operation. The filter reduces the slurry moisture to something between 18 and 20 per cent. before the slurry goes to the kilns. The moisture in the filtered slurry varies with the difference in the raw material, slurry from cleaned stone giving the lowest moisture. This method of operating with excess water, which is removed before burning the slurry, and also cooling the slurry to prevent premature settling, involves the use of a process patented by the Allis-Chalmers Manufacturing Co.

The proportions of the raw materials are 40 per cent. slag and 60 per cent. limestone. The slag is delivered by gravity to a 10-in. fine-reduction gyratory crusher, driven by a 100-H.P. motor which breaks it to 2 in. and smaller. This falls from the crusher into a 20-in. bucket and belt elevator, about 30 ft. high. The drive is by a 5-H.P. motor through a speed reducer. From this elevator the slag goes to a short 18-in. conveyor which has a magnetic pulley to take out pieces of iron. The slag, freed from all the metallic iron that is not too much enclosed, flows through another chute to a 4-ft. cone crusher. This reduces it to $\frac{3}{4}$ in. and finer, the greater part being finer than $\frac{3}{8}$ in. It flows from the crusher to the storage space and it is picked up by the bucket of the travelling crane that serves the raw storage and distributed throughout the storage space as it accumulates.

Raw grinding of the slag-limestone mixture is to more than 90 per cent. through 200-mesh in the " compebs," chrome steel balls and $1\frac{1}{4}$-in. concavex being used as the grinding media. Water is added at the mills. Unusual care is taken to keep the moisture content constant at this point, for this is one of the important features of the process. The slurry flows by gravity to two sumps in the basement of the mill house from which it is sent to the slurry tanks by two pumps each driven by a 40-H.P. motor direct-connected. The drives of all the compeb mills on both the raw and finish grind sides are 500-H.P. synchronous motors connected through magnetic clutches 60 in. in diameter.

There are ten slurry tanks, each 20 ft. in diameter and 28 ft. high over all. Each tank will hold enough for six hours' operation of the kilns, and it is the custom to run on stored slurry over Sunday, the mills having sufficient capacity to accumulate enough slurry for seven days' running in six days. All slurry tanks are provided with agitators, a combination of sweeping arms at the bottom, which draw the slurry to the centre, and a central air lift. The sweeping arms are provided with air jets that help to keep the slurry near the tank wall well stirred. The drive of this agitator is a $7\frac{1}{2}$-H.P. motor through a speed reducer. The air for agitating comes from a low-pressure

23-in. × 12-in. compressor in the power house, driven by a 150-H.P. squirrel-cage motor. Two pumps driven by 40-H.P. motors in the basement of the slurry house transfer the slurry as needed to make corrections or pass it from one tank to another. The piping system permits transfers from any tank to any other tank.

The slurry tanks are connected to form a solid wall and they support a roofed-over structure which covers the agitators. The basement is made wider than the tanks and covered over with a concrete roof resting on walls about 4 ft. above the ground. This gives ample space for working around the tanks where the valves are placed. Either of the two pumps may be used for feeding the filters while the other is transferring slurry or held as a reserve.

Showing how Filter Cake is Removed.

The tanks of the filters serve as kiln feed tanks and are provided with several overflows, one between each pair of discs, to keep the height of the slurry constant.

The filters each have ten discs of 100 sq. ft., so that there are 2,000 sq. ft. of surface altogether. The drive of each is a 5-H.P. direct-current motor through a speed reducer and a worm gear. As the filter serves as a kiln feeder a wide range of speeds has to be provided and the direct-current motor gives this in a simple way. The speed may be varied to anything desired between one revolution in $4\frac{1}{2}$ minutes to one revolution in 9 minutes. Each filter disc is made up of ten sectors and these sectors are readily removable. Whenever a leak occurs the sector containing it is located and withdrawn and

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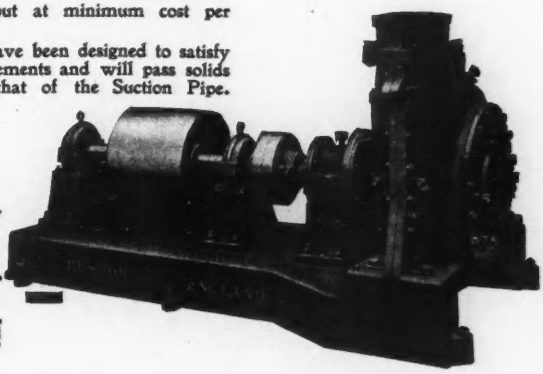

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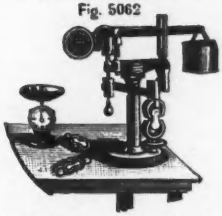
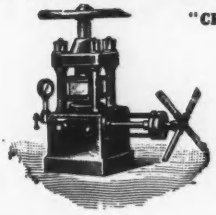
Fig. 5062



"TENSILE" to British Standards.

Fig 5068



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another sector put in its place. As the filter moves slowly the change can usually be made without shutting down.

The cake built up on the filter disc varies according to the material treated, but with clean limestone and slag it is from $\frac{3}{4}$ in. to 1 in. in thickness. With materials more generally used, such as limestone and shale or clay, containing some colloidal matter, the thickness of the cake is less, $\frac{3}{8}$ in. perhaps being an average figure. The vacuum by which the filter cake is built up while the disc is in the tank and afterwards held for the drying out process is furnished by two vacuum pumps, 23 in. by 12 in. Each is driven by a 75-H.P. motor. One pump is ample to serve both filters, so the other is held as a reserve. Between the filters and the vacuum pumps are three vacuum receivers, one of which corresponds to the receivers used with an air compressor except that the air within is under a partial vacuum instead of under pressure. The two small receivers take the water from the filters and discharge it through a pipe into the " barometric sump " below. The large receiver acts during the latter part of the cycle—during drying—also discharging to the barometric sump. They are set high enough (above 32 ft.) so that the vacuum cannot raise the water, and this maintains a vacuum on the discharge of the filter. The vacuum carried is from 23 to 27 in. of mercury, varying with the barometer and the condition of the slurry. Two vacuum pipes are provided for each filter so that different degrees of vacuum may be carried for building the cake and drying out.

For removing the filter cake at the end of the cycle, low-pressure air is used, just enough to distend the canvas slightly and so free the cake. This is furnished by an application of the injector principle. A small jet of compressed air blows into the open end of a 1-in. pipe and carries enough air with it to give a sufficient volume of low-pressure air to do the work. The pressure produced in this way is not enough to offer any damage to the canvas. The clear water drawn from the slurry goes to the barometric sump mentioned and a weir that keeps it full on the lower floor of the kiln house and flows from that to the lake. It does not show more than a slight cloudiness (due to colloidal material) unless there is a break in the canvas. The pieces of filter cake containing 18 per cent. to 20 per cent. of moisture fall through openings between the discs into an open hopper above a 20-in. conveyor belt 20 ft. long, which is a driven by a small motor and a Palmer-Bee speed reducer. From these belts the filter cakes go directly into the kilns through a chute inclined about 45 deg.

There is not much difference in the kiln practice of burning filter cakes in place of liquid slurry, although a greater output can be secured, as there is less moisture to evaporate. In order to handle the greater amount of material for this increased output, a spiral of " super-ascoloy steel," a metal designed to withstand high temperatures, was installed in about 15 ft. of the unlined part of the kiln. The cake, after passing this spiral, travels similarly to the dry material in any kiln. A somewhat higher kiln speed and a somewhat heavier bed of material are carried when burning filtered slurry as compared with the usual practice and an unfiltered slurry.

Company Reports and Accounts.

Ship Canal Portland Cement Manufacturers, Ltd.

AT the recent annual general meeting of the Ship Canal Portland Cement Manufacturers, Ltd., Mr. Oliver J. S. Piper (chairman) stated that the net profit for the year was £137,741, as compared with £138,708. The board recommended the payment of a dividend of 8 per cent. less tax on the Ordinary shares, placing £40,000 to depreciation and carrying forward £33,153. It had been the policy of the board not to restrict operations to the works at Ellesmere Port, but to co-operate with other plants in the production of cement at selective and strategic points, and side by side with the production of a large and increasing output the question of its distribution had been dealt with. The time had come when the interests of the shareholders in this Company, as well as of those in the associated Companies of Greaves, Bull and Lakin (Harbury Works), Ltd., Holborough Cement, Ltd., and of the Ordinary shareholders in the Dunstable Portland Cement Co., Ltd., would best be served by a practical merger of such holdings under one central controlling company.

The most simple and economic way in which that fusion of interests could be effected was to offer to the shareholders of Greaves, Bull and Lakin (Harbury Works) and the Holborough Cement Co. the right to exchange their shares for fully paid Ordinary shares in the Ship Canal Company.

The basis of the proposed exchange was one fully-paid Ordinary share of 4s. in the Ship Canal Company for each fully paid 5s. Ordinary share in Greaves, Bull and Lakin (Harbury Works), and in respect of each fully paid £1 share in Holborough five fully paid Ordinary shares of 4s. each in the Ship Canal Company. It had been agreed by the respective boards to pay dividends of 8 per cent. less tax for the year to June 30th last on the Ordinary shares of Greaves, Bull and Lakin, and an interim dividend at the rate of 8 per cent. per annum for the six months to that date on the shares of Holborough Cement. The balance of the Ordinary shares of Dunstable Portland Cement would be acquired for cash, and except for 706 shares which had not come into the earlier purchase scheme, the whole of the ordinary capital of that Company would be under the control of the Ship Canal Company.

It had also been decided, with the sanction of the Board of Trade, to change the name of their company to Allied Cement Manufacturers, Ltd., as indicative of its enlarged sphere of operations. To carry out the various objects in view an increase in the existing capital had become necessary. The Board proposed to create 850,000 new 7½ per Cent. Convertible Preference shares of £1 each and 15,000,000 new Ordinary shares of 4s. each. It was proposed to issue the new Preference shares giving preferential consideration to existing shareholders; part of the new Ordinary would be subscribed in cash, and the balance would remain in reserve; it was also proposed to convert the existing 15s. Preference shares into £1 Convertible Preference shares on the basis of four for three, and to give to all Preference shareholders the right at any time within three years to convert a £1 Preference share into five Ordinary shares of 4s. on payment of 30s. per Preference share.

When all arrangements were completed their company would hold absolute control over the Ellesmere Port Works in the North, the Harbury Works in the Midlands, the Dunstable Works in the East Midlands, and the Holborough Works, the Smeed Dean Works, and the British Standard Works in the South-Eastern area with a combined capacity of over 1,000,000 tons of cement per annum.

Combined with that were the important factors of distribution. The whole of the share capital of J. and W. Henderson, Ltd. (including Ernest Mathews and Co.), and T. and J. Graham, Ltd., came into possession of the Company, and they would also have an effective control of Wiggins and Co. (Hammersmith), Ltd.

Aberthaw and Bristol Channel Portland Cement Co., Ltd.

THE Directors' report and statement of accounts of this Company for the year ended March 31, 1929, states that during the year under review the demand for cement was only sufficient to enable the plant to be worked at little more than half capacity, and, owing to keen competition in the cement industry, the prices obtained for the